FLORIDA INTERNATIONAL UNIVERSITY
Miami, FL

PROPOSAL FOR RESEARCH THESIS

MASTER OF SCIENCE IN COMPUTER SCIENCE

COLLEGE OF ARTS AND SCIENCES

SCHOOL OF COMPUTER SCIENCE

Sonia Otero

I propose to the Major Professor and to the Committee Members a study of the following topic to be conducted in partial fulfillment of the requirements for the degree of Master of Science in Computer Science: A REAL-TIME DISTRIBUTED ANALYSIS AUTOMATION FOR HURRICANE SURFACE WIND OBSERVATIONS.

This thesis proposes the design and implementation of a distributed object application for the real-time analysis of quality controlled tropical storm surface wind observations. The analysis application will be integrated with a World Wide Web and database based application that handles the quality control of those wind observations.

Based on Powell, et. al. [1], analysis are produced by compositing all available observations relative to the storm center that is studied. Observations include Air Force and NOAA aircrafts, ships, buoys, Coastal Marine Automated Network (C-MAN) platforms and surface airways (airports). First, the data are quality controlled, and then processed to conform to a common framework for height (10 m), exposure (marine or open terrain over land), and averaging period (maximum sustained 1 minute wind speed). It takes several hours of collected observations to provide sufficient data to produce an objective analysis, which represents the mean state of the storm during the chosen time period. A typical 10-hour reconnaissance mission will yield two to three analyses.

The primary product of each analysis is a streamline and isotach contour plot, designed to convey the location and strength of the maximum wind as well as the extent of hurricane force winds. Naturally, the analysis results help meteorologists determine the storm's most recent measured intensity and the extent of its damaging winds, which can, in turn, help them in issuing storm forecasts and warnings. Timely analyses results combined with geographic information of the area affected by a landfall of a hurricane or tropical storm can help identify which locations suffer the most intense winds and severe storm surge. Early data acquisition should help emergency managers to better organize

search, rescue and recovery operations shortly after the disaster has taken place. Given the importance of this information, some commercial and scientific communities have also expressed interest in accessing hurricane wind field data in a graphical or flat file format.

Current System

The Hurricane Research Division (HRD), located in Key Biscayne, under the National Oceanic and Atmospheric Administration (NOAA), has been producing real-time analyses of tropical storm surface wind observations since 1993 [2], on an experimental basis. The overall application that comprises workstation based quality control, partially automated analysis process and graphics output was named WANDA (Wind Analysis Distributed Application). From a general perspective, the application's operation starts with the fetching of data from a flat-file repository. FTP scripts regularly update this repository to download near real-time data from the National Hurricane Center for Environmental Prediction (NCEP) via the National Hurricane Center (NHC), located at the Florida International University campus. Secondly, the data are processed and quality controlled, sent to the analysis server, and finally, the output is displayed and converted to a format that can be faxed or hard copied to clients, such as NHC's hurricane specialists.

WANDA is logically divided in three independent subsystems: 1) Quality Control, 2) Analysis Automation, and 3) Output Generation. One could look at them as highly cohesive decoupled classes.

1) Quality Control

This is the graphical user interface to WANDA, which resides on a workstation. Through a sequence of windows, the user selects a set of observations and an associated storm track, that are then displayed according to the geography of the selected storm. Several inspection tools are provided to the user to decide the validity of the data and thus make the final selection of a satisfactory set that should be analyzed.

2) Analysis Automation

The quality-controlled data and a storm track are passed through a series of Analysis subsystem components. Each component is distributed over two machines, a NeXTSTEP client and a VAX/VMS server where the legacy analysis programs reside. WANDA uses state machines to orchestrate all of the state transitions involved in the analysis automation. Included in this automation is the automatic archival of all steps of an analysis for future research purposes. Any analysis can be traced back to its components' results and data sets. The state automata approach ensures that the execution of an analysis component can only start if no errors have been encountered previously, which are reported accordingly.

3) Output Generation

The Output Generation subsystem creates a graphical representation of the wind fields. The implementation of this subsystem is done with an in-house graphics package that displays an analysis product on the client workstation where the user can annotate and save it to an encapsulated postscript document.

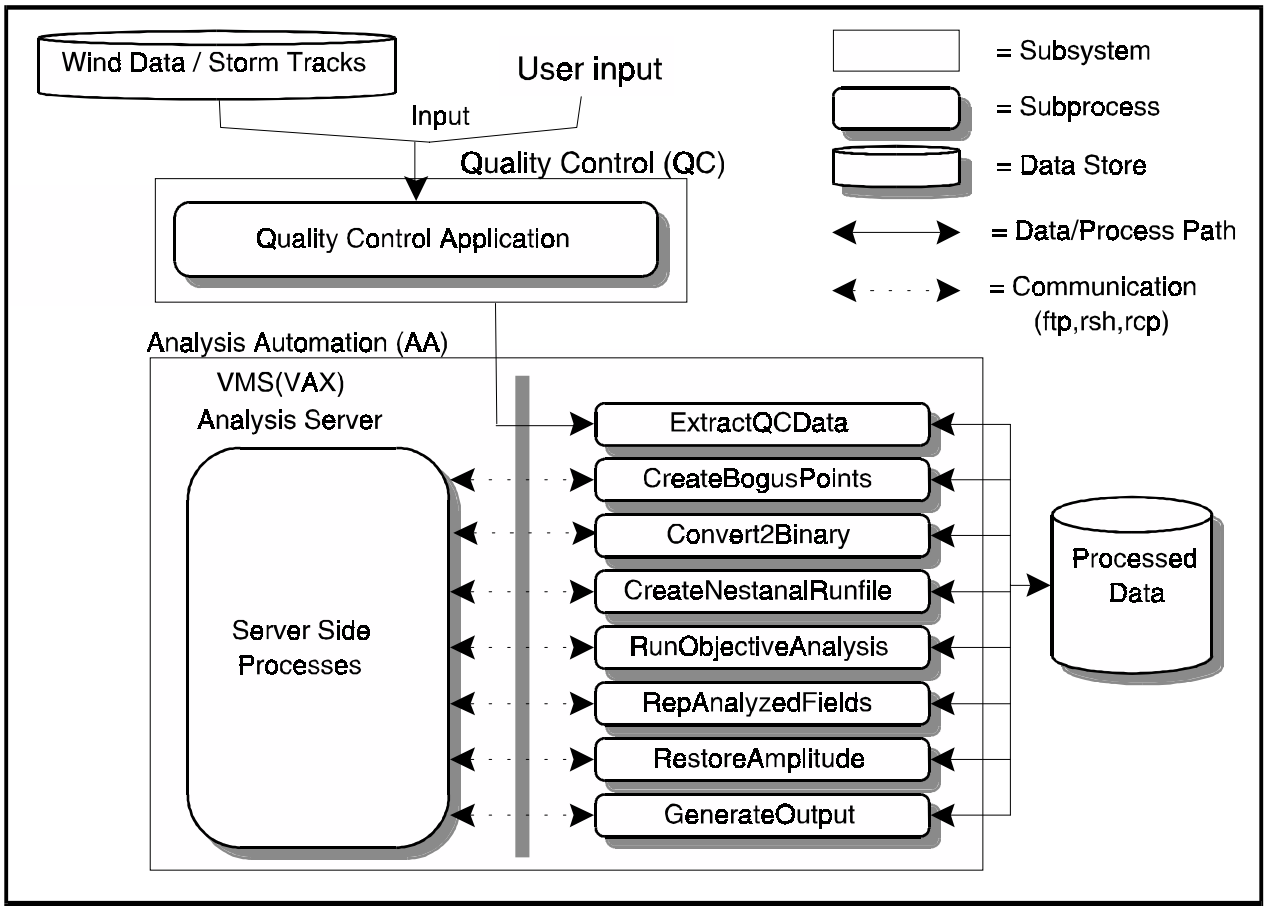

Fig 1. Process and data flow diagram for the current WANDA

Why is the current system not good enough? One of the major drawbacks is the lack of a database common and accessible by all the subsystems. The use of a hierarchy of flat files makes the application platform specific plus inhibits flexibility for manipulating data retrieval. Also, data integrity and security issues are raised due to the use of ftp, rsh and rcp scripts. The lack of portability is another problem. NeXTSTEP and VAX/VMS systems are not precisely in high demand and both have uncertain futures. Regardless of the platform, however, one of the goals for WANDA is to become truly distributed and to be used on a continuous basis both at HRD and at NHC. Because HRD is located in Key Biscayne, a hurricane warning for Dade County would mean that the facility housing

WANDA's primary resources would have to be shutdown. There is a need for maintaining redundant analysis and database servers at NHC as well, capable of performing the same exact tasks described earlier. Ideally, both analysis and database servers would be running simultaneously for maximum capacity. Therefore, load balancing and concurrency factors need to be taken into consideration. The ability to reuse portable code is crucial in order to keep this redundancy as transparent as possible.

Proposed System

WANDA will be going through a tremendous reconstruction, and is expected to be ready for the 1998 hurricane season. The future version of WANDA will be made up by three main areas of development, aimed to improve the drawbacks listed above. They all have in common the exploitation of the Object Oriented paradigm:

- Database management system incorporation is already underway.

This will greatly ease the retrieval and storage of all the data involved throughout all the phases of the application. WANDA's database design was the topic of a Master's Thesis at Florida International University [3].

- The use of the platform independent object oriented programming language (OOPL), Java, for WANDA's Quality Control subsystem, in order to comply with the World Wide Web requirement. The discussion about WANDA's Quality Control subsystem is the subject of a Master's Thesis that has been proposed at Florida International University.
- The use of Distributed Objects (DO) technology for the Analysis Automation subsystem, for which this proposed thesis will be mainly responsible. The source

code that involves all the steps of an analysis run is already written and is maintained in FORTRAN by expert meteorologists. It is a task that will remain managed by them, until or if a decision is reached to port the code to OOPL. As a result of this situation, the FORTRAN code needs to be wrapped in an OOPL (most likely Java, to homogenize with the rest of the project as much as possible) that not only allows database connectivity, but more importantly, transforms each analysis step into an object that can then be used as a distributed object. The implementation will undoubtedly include the use of a CORBA-compliant (Common Object Request Broker Architecture) IIOP (Internet Inter-Orb Protocol) Object Request Broker (ORB), which is the Object Management Group's (OMG) well-established and widely adopted standard for object interoperability and communication. In addition, given the extended use of Java throughout both the Quality Control and the Analysis Automation subsystems, it would be perfectly sound to implement a version that uses Java's own distributed programming model, Remote Method Invocation (RMI), as it is recommended for Java-to-Java interprocess communication.

The FORTRAN programmers/meteorologists have already adapted the VAX/VMS code for UNIX execution. Analysis Automation is inherently constrained by its FORTRAN implementation, but once it becomes part of the distributed object infrastructure, through an Interface Definition Language (IDL) declaration, it can be freely invoked completely independent of the programming language, operating system or network to which it is tightly bound. This is especially important for HRD to achieve true application

distribution. CORBA's features provide many DO advantages: transaction control, concurrency, and event notification. These characteristics take advantage of some well-known properties of OO, like encapsulation, inheritance and polymorphism.

Besides the development of the DO section of WANDA, my duties will include the completion of the analysis of the database schema for the archival of the Analysis Automation results, plus the later connectivity to the database server as well. In addition, I will provide a client GUI for the acquisition of the Analysis parameters needed to run an analysis process. Finally, the distributed Analysis Automation subsystem will be integrated with the future version of the Quality Control application.

The software engineering methodology to be followed will be the iterative model. The plan is to constantly revise with the user if the requirements are being met after a certain amount of progress has been done. WANDA's project team is small and the contact with relevant key users is close and frequent, which makes it easy for the iterative development approach to work (Yourdon, 43). Upon completion of this proposed thesis, the OO Analysis (OOA) and OO Design (OOD) documents will be submitted, along with object interaction diagrams, object life history diagrams and some user scenarios. The OMT notation will be followed.

Bibliography

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